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BIPOLAR PLATE WITH TWO METAL PLATES FOR A FUEL CELL AND ITS FABRICATION METHOD
[PLAQUE BIPOLAIRE A DEUX PLAQUES METALLIQUES POUR PILE A COMBUSTIBLE ET SON PROCEDE DE FABRICATION]

J. E. Chaix

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Inventor	:	J. E. Chaix
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BIPOLAR PLATE WITH TWO METAL PLATES FOR A FUEL CELL AND ITS FABRICATION METHOD

Abstract

The bipolar plate is relatively light and can be fabricated quickly and simply.

It is comprised of a framework of two metal plates (30) separated by some contacts (34, 35) between which a refrigeration fluid circulates. The fuel and combustive material collectors supply, through the intermediary of delivery channels (33), the circulation channels (211) of a body (20) with a conducting composite material. The latter is molded in a single operation, some holes being provided in the metal plates (30) to perform the molding in a single operation.

Application: for fuel cells.

DESCRIPTION

Area of the invention

The invention concerns the field of fuel cells comprised of a stack of a large number of base cells, each of which includes two polar plates through which the combustive material and the fuel are led toward a separating membrane placed between the two polar plates.

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[1] Numbers in the margin indicate pagination in the foreign text.

This kind of fuel cell can have applications in electric powered vehicles that presently are the object of many research and development projects, surface urban transport vehicles in particular such as buses, streetcars and other trolley buses. Many other applications are possible, especially at permanent facilities such as stationary electricity production systems, like those used in hospitals or other service buildings where the possibility of electricity power supply interruption must be eliminated.

The prior art and the problem posed

Many fuel cells are comprised of a series of base cells that include themselves two electrodes, of which one is an anode and the other a cathode, to which a combustive substance and a fuel are brought continuously, which remain separated by an ion exchange membrane that serves as an electrolyte. The ion exchange membrane can be formed from a solid polymer electrolyte and separates the anode compartment, where oxidation of the fuel occurs, such as hydrogen, from the cathode compartment, where the fuel, such as oxygen from the air, is reduced. Two simultaneous reactions therefore occur at this stage, the oxidation of the fuel at the anode and the reduction of the combustive substance at the cathode. These two reactions are accompanied by the establishment of a potential difference between the two electrodes.

When the combustive substance is oxygen, in the form of air for example, and the fuel is gaseous pure hydrogen, the $H^{=}$ and O^{-} ions combine and produce electricity in the form of this potential difference. The reaction can be shown in detail in the following way at the anode:

$$2H_2 + 4OH^{-} > 4H_2O + 4e^{-}.$$

The reaction at the cathode is explained by the following formula:

$$O_2 + 2H_2O + 4e^{-} > 4OH^{-}.$$

Each base cell of a stack of a fuel cell is comprised of a central unit that therefore includes the membrane, used in a sandwich between the two electrodes, this unit itself being placed between two side plates, called "polar plates." The latter have several functions.

The first of these functions is to bring into contact the unit that combines the membrane and the electrodes, on one side the fuel, hydrogen for example, and on the other side the combustive substance, air containing oxygen for example. To accomplish this a channel is provided over the entire side of the polar plates in contact with the membrane. Each channel has an entrance through which the combustive substance or the fuel penetrates, in dry or moist gaseous form for example, and an exit through which the neutral gases are removed, the water generated by the oxidation-reduction reaction for the air and the residual

moistness of the hydrogen for its part. Of course, the two circuits must be perfectly airtight with respect to one another and each one vis-à-vis the outside.

The second function of the polar plates is to collect the electrons produced by the oxidation-reduction reaction.

The third function of these polar plates is to ensure the removal of the calories produced jointly with the electrons at the time of this hydrogen reduction reaction.

Consequently, these polar plates are therefore necessarily, on the one hand, conductors of electricity and, on the other hand, insensitive, from the standpoint of corrosion, to the fuel and the combustive substance, that is to the oxygen from the air and the hydrogen. Therefore, they can be made of carbon, a plastic material, filled with a stainless alloy such as stainless steel, austenite-ferrite steel, austenite steel, a chrome-nickel alloy, aluminum coated with chromium, and so forth. /4

On the other hand, within the fuel cells comprised of a stack of base cells, the polar plates also assure a collective function for the entire stack, such as preparing the supply collectors with fuel and combustive substance, and the thermal exchange function, thus allowing the refrigeration of the cell made of the stack. The polar plates are therefore of complex shape and frequently of two different kinds, one for each side of the base cell.

As part of the construction of fuel cells, in order to reduce the production cost, there is a need to limit the fabrication stages of the polar plates, in particular the lengthy and expensive operations of machining.

The aim of the invention is to propose a design of base cells and of unique polar plates that is simple and not very expensive to fabricate.

Summary of the invention

For this purpose the first main goal of the invention is a bipolar plate that comprises the first polar plate of a first base cell of a fuel cell and the second polar plate of a second base cell adjacent to the first base cell of the same fuel cell, which includes: /5

- A framework comprised of two thin metal plates, parallel, separated and attached to one another by some contacts and thus delimiting a refrigerant stage;
- A single body made of a conducting composite material comprised of two layers distributed on both sides of the framework, except on the edge, and on each free surface of which at least one combustive substance or fuel circulation channel is formed;
- A frame of dielectric thermoplastic material and comprised of two layers placed on both sides of the framework;

- Some collector holes being provided on the periphery of the plates and the frame comprising the combustive substance and fuel collectors, some supply channels located between the plates that connect each collector hole to a circulation channel.

In the preferred implementation of the bipolar plate according to the invention the two metal plates are perforated with non-peripheral molding holes in order to allow the conducting composite material to be distributed on both sides of the framework at the time of fabrication by molding.

Preferably, the metal plates are aluminum, Normes AIR 2024 type.

The material that comprises the body is, preferably, a composite material loaded with carbon. /6

The framework advantageously is complemented with perforated contacts, which are placed around some collectors that are comprised of the collector holes and placed between the two metal plates to contribute to the continuity of the collectors.

It turns out to be very advantageous to use some silicone joints installed on the surfaces of the frame, around the holes that comprise the collectors of fuel and combustive substance and on the periphery of the membrane of a membrane/electrodes set in order to assure air-tightness between two bipolar plates.

When each bipolar plate has a square shape, at least one circulation channel of fuel or combustive substance of each bipolar plate surface has a squared-off helical shape.

A second main goal of the invention is a method of fabricating a bipolar plate, such as it is defined in the preceding paragraphs.

The main stages are successively the following:

- Integration of the metal plates with one another by means of contact studs or by gluing;
- Molding, around the framework as made, of the body of the conducting composite substance, especially by means of the molding holes made in the metal plates; and
- Injection of the frame made of a thermoplastic material.

At the same time as this third stage is carried out the injection of silicone joints on the frame surfaces can be accomplished. /7

List of figures

The invention and its different characteristics and advantages will be better understood from reading the following description of one implementation of the invention. It is accompanied by four figures that show respectively:

- Figure 1, in sectional view, two bipolar plates according to the invention;

- Figure 2, another sectional view of the same bipolar plate according to the invention;
- Figure 3, in a bird's eye sectional view, the corner of the bipolar plate according to the invention; and
- Figure 4, a top view, a bipolar plate according to the invention.

Detailed description of one implementation of the invention

In figure 1 two membrane/electrodes sets 1 and two bipolar plates 10 are shown. Each membrane/electrodes set 1 is therefore comprised of a membrane 3 surrounded by two electrodes 2 over its entire surface, except for the periphery. Each of these membrane/electrodes sets 1 must be placed between two bipolar plates 10.

Each bipolar plate 10 includes mainly a framework around which a body 12 made of a composite material, in the central part, and a frame 11 made of dielectric material in the peripheral part, are secured. /8

The framework is comprised essentially of two plates 30, made of metal and having small thickness, separated from one another by 1 to 2 mm. They are advantageously made of type 2024 Normes AIR aluminum, called "aviation" aluminum. They are secured in this position by means of contact studs not shown in this figure. A space 31 is thus delimited in the center of this unit and is intended to receive and to contain the circulation of

the refrigeration fluid, such as water that is provided to refrigerate each stage of the stacking of the fuel cell.

The metal plates 30 are perforated with several holes on their periphery in order to contribute to the formation of continuous collectors 15 of combustive substances and fuel and they also allow one to pass through them some tie bolts, not shown, which assure attachment of the different stages of the fuel cell. It has been established that, in the area of these collectors 15, the two metal plates 30 define a second space that is a supply channel 33, isolated from the first space 31 by means of a hollow supply contact stud 32. The latter also surrounds the collector 15 and a supply opening 22 for fuel or combustive substance that opens into the body 20 in the area of a circulation channel 21S, which itself opens onto the external surface of the unit.

Thus, it is easy to understand that each electrode of the membrane/electrodes 1 sets can be in contact with the fuel or the combustive substance, when the membrane/electrodes set 1 is placed between two bipolar plates 10, as shown in the low part of the figure. A membrane joint 4 is placed in a peripheral gap 13 that surrounds the body 20. /9

We found that a supply channel 33 supplies only the upper circulation channel 21S. Indeed, the collector comprised of the collector hole 15 shown in this figure 1 and other parts contains

only fuel or combustive substance. In the same way, other collectors contain the fuel that is complementary to that circulating in the circulation channel 21S to supply the lower channels 21I. Thus, each body will be able to cause the circulation of fuel in the first of its circulations 21S, on one first side and, on the other side, combustive substance in a second circulation channel 21I.

With reference to figure 2 it is necessary only that all the collector holes are in communication with one of the two circulation channels 21S and 21I through the intermediary of a supply channel 33. Consequently, figure 2 shows a second kind of collector hole 16 that is not in fluid communication with the circulation channels 21S and 21I. In this case, the internal wall of each collector hole 16 is comprised entirely of the frame 11. For this purpose, each metal plate 30 has a hole with diameter greater than the internal diameter of the collector in order to allow the material, dielectric thermoplastic for example, that comprises the frame 11 to occupy the entire height of the polar plate in this area. /10

In this figure 2 one can therefore determine that the space 31 remains between the two metal plates 30 for the circulation of the water that contributes to refrigeration of the cell.

In order to facilitate the fabrication of the body 12, the metal plates 30 are also perforated with several molding holes in

the part that corresponds to that of the body 20 in order to allow, during molding of the constituent material of the body 20, to pass through both sides of the framework, comprised of the two metal plates 30. This allows one to accomplish, in a single operation, the formation by molding of the body 20 around the framework. This operation is carried out under pressure and is followed by polymerization of the composite material that is thus formed.

One can see in figures 1 and 2 that spot facing 18 is provided on each of the two surfaces of the frame 11, inside of the latter, in order to allow positioning and support of each membrane 3.

Figure 3, the cutaway view type, allows one to better understand, among other possibilities, the difference between the two kinds of collector holes. Indeed, on the right part of this figure 3 a collector hole 15 is located, as shown in figure 1. It therefore places in communication the fuel or the combustive substance that circulates in the collector, which it comprises with the other collector holes placed above and below it, with the circulation channel 21I, through the intermediary of the supply channel 33 and some supply holes 22. In this case one can clearly distinguish the hollow supply contact stud 32 that surrounds both the collector hole 15 and the supply hole 22 to form the supply channel 33. /11

In the middle of this figure 3, between the two metal plates 30, one will find a contact stud 34, equipped with a molding hole 36. The latter allows the composite material that constitutes the body 20 from splitting up, during its molding, on both sides of the two metal plates 30. The function of this contact stud 34 is therefore to support the two metal plates that are separated from one another in such a way as to define the different spaces, mentioned previously, which are the first space 31, intended for the refrigeration of the cell by water, and the supply channels 33. One will note that the first spaces 31 are in communication with the outside by means of some outlets 37. In this way, the fuel cell assembly, comprised of the stacking of different stages, each of which includes a membrane/electrodes set and two polar plates, is bathed in a water bath in order to facilitate its refrigeration by free circulation of the refrigeration fluid, water for example.

On the right part of this figure 3 one can see that another kind of contact stud 35 is provided to surround the collector holes 16 of the second kind and to support the two metal plates 30 at a suitable distance.

In this figure 3 it is easy to see the rectangular peripheral shape of the peripheral joint 4 and the circular shape of the collector joints 5. /12

Figure 4 shows, overall, a bipolar plate and, more particularly, the manner in which the circulation channels 21S and 21I are arranged on a surface of such a bipolar plate. In the example shown, four circulation channels 21S are installed on the same surface of a bipolar plate 10. Each of these circulation channels 21S has a squared-off spiral shape, of which one can distinguish the center 23. Each of them is supplied by one of the collectors, shown here with their collector holes 15 and 16, and is drained by another of these same collectors. Since there exists the same number of circulation channels on the other side of the bipolar plate, the number of collectors is thus doubled. In other words, with four circulation channels 21 on each side of the bipolar plate, eight supply collectors and eight evacuation collectors are necessary. The arrows, shown on this figure 4, suggest therefore that there are supplies and drains of each of the eight circulation channels of a single bipolar plate.

The hollow contact studs 32, one supply opening 22 and one supply channel 33 are also shown in broken lines. Also, all the contact studs 34 that support the metal plates separated from one another in parallel manner are shown in broken lines.

The fabrication method of this kind of bipolar plate is accomplished therefore by an initial phase that consists in building a framework comprised of the two metal plates 30,

preferably made of aluminum, and of the contact studs 32, 34 and 35 by cold gluing. /13

Molding of the body 20 made of a conducting composite material is then carried out under pressure, the material penetrating into the molding holes 36 in the middle of the metal plates 30.

Polymerization terminates the fabrication of the body 1.

The frame is produced by injection of a dielectric thermoplastic material. At the same time as this injection there is injection of the collector 5, peripheral 4, and supply joints 32 with silicone.

Advantages of the invention

This bipolar plate structure is particularly light, since it uses aluminum and plastic.

The fabrication is relatively simple and the machining operations are few in number. /14

CLAIMS

1. Bipolar plate that comprises the first polar plate of a base element of a fuel cell and the second polar plate of a second base element adjacent to the first base element of the same fuel cell, which includes:

- A framework comprised of two metal plates (30) that are parallel, separated from one another and secured to one another by some contact studs (32, 34, 35) and thus

delimiting a first space (31) to allow circulation of the refrigerant;

- A single body (20), made of a conducting composite material comprised of two layers that extend over both sides of the framework, except on the edge, and on each free surface of which at least one circulation channel (21S, 21I) is formed for the fuel or combustive substance; and
- A frame (11) made of dielectric thermoplastic material placed on both sides of the framework and around the body (20);

Some collector holes (15, 16) being provided on the periphery of the metal plates (30) and of the frame (11) to comprise collectors of fuel and combustive substance, some supply channels (33) located between the plates, which connect these collector holes (15, 16) to the circulation channels (21S, 21I).

2. Bipolar plate according to claim 1 characterized in that the two metal plates (30) are perforated by non-peripheral molding holes to allow the conducting composite material that comprises the body (20) to be spread on both sides of the framework during the fabrication of the body by molding. /15

3. Bipolar plate according to claim 1 characterized in that the metal plates (30) are made of Normes AIR 2024 type aluminum, called "aviation" aluminum.

4. Bipolar plate according to claim 1 characterized in that the body (20) is a composite material loaded with carbon.

5. Bipolar plate according to claim 1 characterized in that the framework includes some perforated contact studs (35), placed around some collectors comprised of the collector holes (16) and placed between the two metal plates (30) to contribute to the continuity of the collectors of fuel and combustive substance.

6. Bipolar plate according to claim 1 characterized in that it includes some silicone joints (4, 5) installed on the surfaces of the frame (11) around the collectors of fuel and combustive substance and on the periphery of the membrane (3) of a membrane/electrodes set (1) to assure air-tightness between two bipolar plates.

7. Bipolar plate according to claim 1, the shape of the bipolar plate being square, characterized in that at least one circulation channel (21S, 21I) of each surface of the body (20) has a squared-off spiral shape.

8. Method of fabricating a bipolar plate according to claim 2 characterized in that it includes the following successive stages: /16

- Integration of the two metal plates (30) to one another by means of the contact studs (32, 34, 35) by gluing;

- Molding, around the framework, of the body (20) made of conducting composite material, especially by means of the molding holes (36) made in the metal plates (30);
- Injection of the frame (11) with dielectric thermoplastic material.

9. Fabrication method according to claim 8, of a bipolar plate according to claim 7, characterized in that it consists, simultaneously with the third injection stage of the frame (11), in injecting the joints with silicone (4, 5) on the surface of this frame (11).

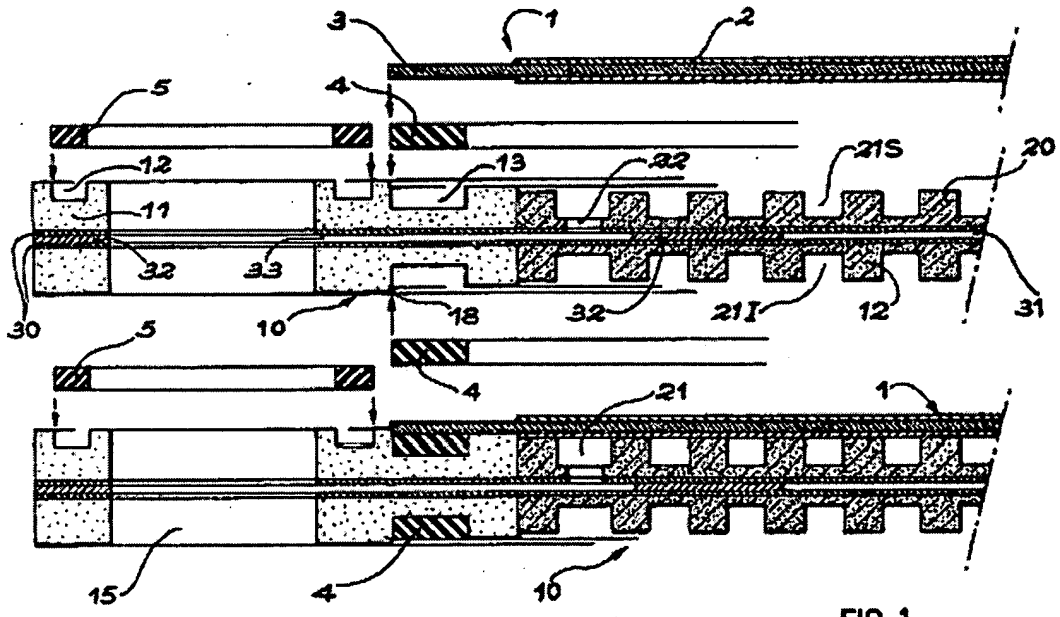


FIG. 1

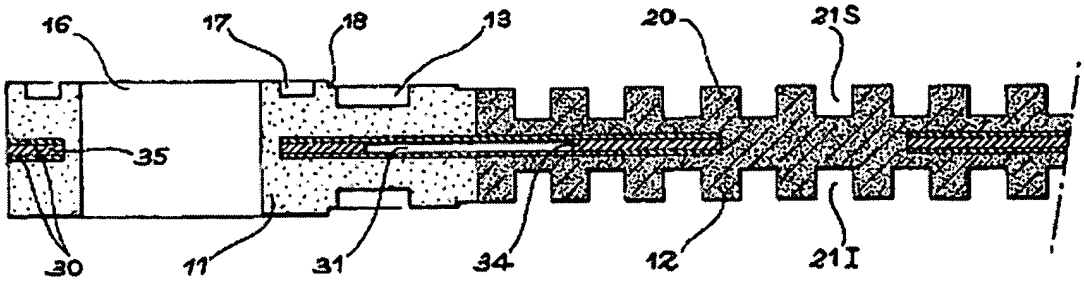
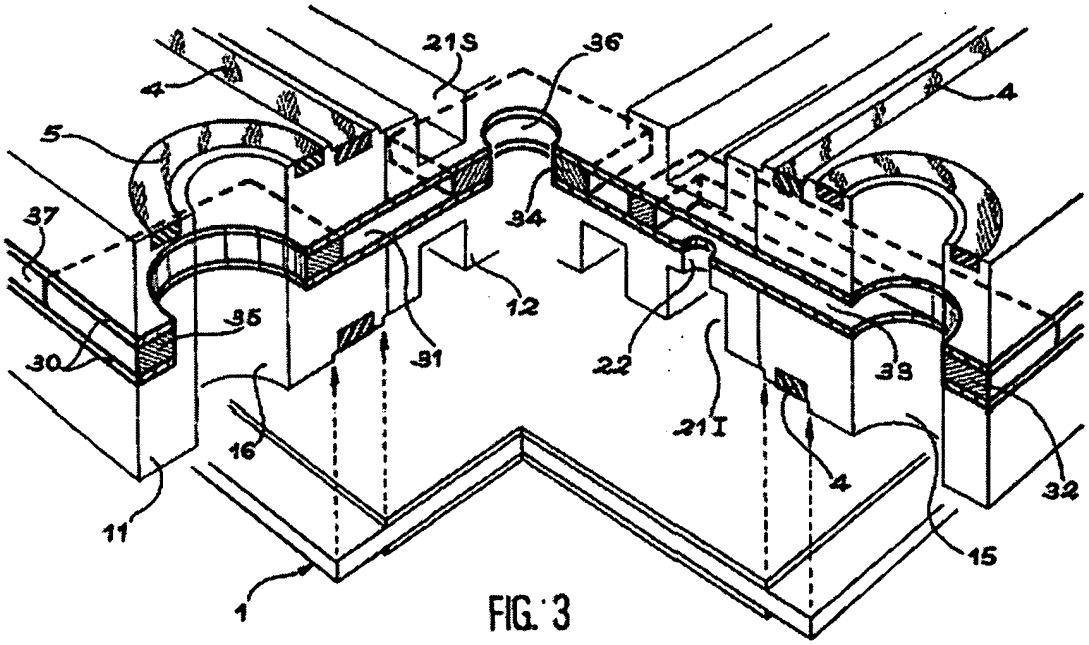

16
17
18
13
20
21S
35
30
11
31
34
12
21I

FIG. 2


21S
36
4
4
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37
34
12
35
30
31
22
38
21I
16
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32
11
15
1

FIG. 3

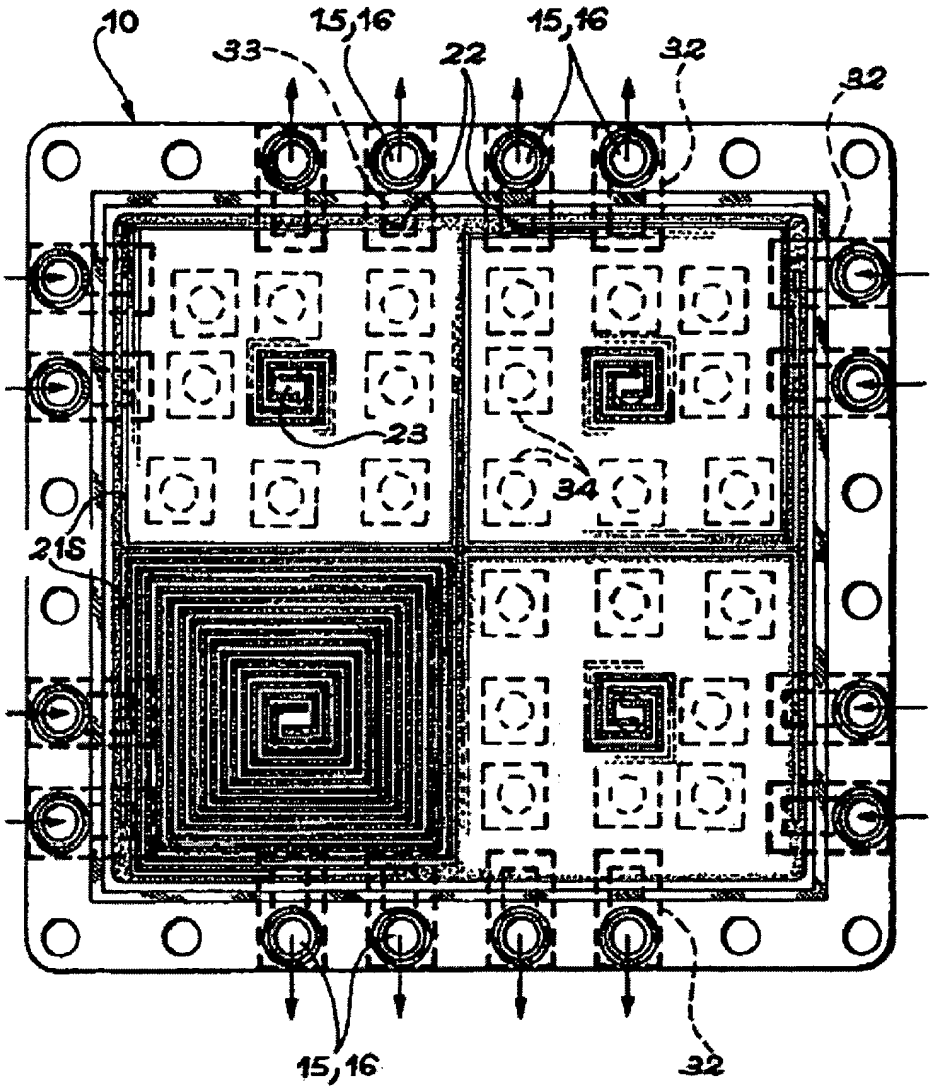

FIG. 4